

Application No. 10/628,936  
Response to Office Action

Customer No. 01933

Listing of Claims:

1. (Currently Amended) An ink-jet recording apparatus comprising:

5 a recording head having an ink channel and ~~(a) a nozzle of an ink channel in a recording head, from which an ink droplet is~~ jetted; and

~~(b) an electromechanical converting device for changing a volume of the ink channel to make the~~ cause an ink droplet to jet ~~be jetted from the nozzle; [[,]]~~

10 wherein before an ink droplet jetting operation is conducted and without jetting the ink droplet, an ink meniscus in the nozzle is vibrated finely by ~~repeating plural~~ performing a plurality of times: (i) a pushing out process so of pushing the ink meniscus out from a surface of the nozzle such that a peak distance corresponding to ~~a peak~~ of the ink meniscus ~~pushed out~~ from ~~a~~ the surface of the nozzle is at least substantially equal to ~~or more than~~ a radius of the nozzle, and (ii) a pulling process ~~for of~~ pulling in the ink meniscus into the nozzle more toward the ink channel ~~across past~~ a repose position of the ink meniscus, ~~while the ink is prevented from jetting from the~~

20 nozzle.

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2. (Currently Amended) The ink-jet recording apparatus of claim 1, wherein drive signals ~~having~~ are repeatedly applied a plurality of times to the electromechanical converting device to conduct the fine vibration of the ink meniscus, and said drive  
5 signals include: a voltage pulse with a pulse width of  $(N_1)AL$  for expanding the volume of the ink channel, a first pause period with a width of  $(N_2)AL$ , a voltage pulse with a pulse width of  $(N_3)AL$  for reducing the volume of the ink channel, and a second pause period with a width of  $(N_4)AL$ ; ~~are applied repeatedly plural times to the electromechanical converting device, thereby a fine vibration of the ink meniscus is conducted,~~  
10

where:

$AL$  represents a half of an acoustical resonance period of the ink channel,

15 each of  $N_1$  and  $N_3$  is an integer of at least 2 or more,  
and

each of  $N_2$  and  $N_4$  is a real number of at least 1 or more.

3. (Currently Amended) The ink-jet recording apparatus of claim 1, wherein drive signals ~~having~~ are repeatedly applied a plurality of times to the electromechanical converting device to conduct the fine vibration of the ink meniscus, and said drive  
5 signals include: a voltage pulse of rectangular wave with a pulse

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width of  $(N_1)AL$  for expanding the volume of the ink channel, a first pause period with a width of  $(N_2)AL$ , a voltage pulse of rectangular wave with a pulse width of  $(N_3)AL$  for reducing the volume of the ink channel, and a second pause period with a width of  $(N_4)AL$ ; ~~are applied repeatedly plural times to the electromechanical converting device, thereby a fine vibration of the ink meniscus is conducted,~~

where:

AL represents a half of an acoustical resonance period of the ink channel,  
each of  $N_1$  and  $N_3$  is an integer of at least 2 ~~or more~~,  
and  
each of  $N_2$  and  $N_4$  is a real number of at least 1 ~~or more~~.

4. (Currently Amended) The ink-jet recording apparatus of claim 3, wherein each of  $N_2$  and  $N_4$  is an integer of at least 1 ~~or more~~.

5. (Original) The ink-jet recording apparatus of claim 3, wherein each of  $N_1$ ,  $N_2$ ,  $N_3$  and  $N_4$  is 4.

6. (Currently Amended) The ink-jet recording apparatus of claim 3, wherein a jetting drive voltage that ~~makes the~~ causes

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the ink droplet to ~~jet be jetted~~ from the nozzle ~~in the recording head and to record images~~, is equal to a fine vibration drive voltage that ~~vibrates finely~~ causes the ink meniscus to vibrate finely without ~~making an~~ causing the ink droplet to ~~jet be jetted~~ from the nozzle.

7. (Currently Amended) The ink-jet recording apparatus of claim 6, wherein when the recording head is outside an image recording area, an ink refreshing drive to spew ink is carried out by driving the electromechanical converting device, and ~~each~~ of wherein a jetting drive voltage ~~when the~~ for image recording ~~is conducted~~, a fine vibrating drive voltage that ~~makes~~ causes the ink meniscus to vibrate finely, and an ink refreshing drive voltage ~~, is the same~~ are equal.

8. (Currently Amended) The ink-jet recording apparatus of claim 1, wherein ~~a~~ the peak distance of fine vibration of an the ink meniscus from the nozzle is greater when the recording head is outside ~~the an~~ an image recording area, ~~is greater than that of fine vibration of an ink meniscus than~~ when the recording head is on a non-recording pixel in the image recording area.

9. (Currently Amended) The ink-jet recording apparatus of claim 3, wherein the electromechanical converting device forms a

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partition wall between adjacent ink channels, and ~~is of~~ comprises  
a piezoelectric material that deforms ~~under~~ in a shear mode.

10. (Currently Amended) An ink-jet recording apparatus  
comprising:

a recording head having an ink channel and ~~(a) a nozzle of~~  
~~an ink channel in a recording head, from which an ink droplet is~~  
5 ~~jetted; and~~

~~(b) an electromechanical converting device for changing a~~  
~~volume of the ink channel to make the~~ cause an ink droplet to jet  
be jetted from the nozzle; [[,]]

wherein drive signals having are repeatedly applied a  
10 plurality of times to the electromechanical converting device to  
finely vibrate an ink meniscus without jetting an ink droplet  
from the nozzle, and said drive signals include: a voltage pulse  
with a pulse width of  $(N_1)AL$  for expanding the volume of the ink  
channel, a first pause period with a width of  $(N_2)AL$ , a voltage  
15 pulse with a pulse width of  $(N_3)AL$  for reducing the volume of the  
ink channel, and a second pause period with a width of  $(N_4)AL$ ;  
~~are applied repeatedly plural times to the electromechanical~~  
~~converting device, thereby a fine vibration of the ink meniscus~~  
~~is conducted, while the ink is prevented from jetting from the~~  
20 ~~nozzle,~~

where:

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each of  $N_1$  and  $N_3$  is an integer of at least 2 or more,  
each of  $N_2$  and  $N_4$  is a real number of at least 1 or  
more, and

25 AL represents a half of an acoustical resonance period  
of the ink channel.

11. (Currently Amended) An ink-jet recording apparatus  
comprising:

a recording head having an ink channel and ~~(a) a nozzle of~~  
~~an ink channel in a recording head, from which an ink droplet is~~  
5 ~~jetted; and~~

~~(b) an electromechanical converting device for changing a~~  
volume of the ink channel to ~~make the~~ cause an ink droplet to jet  
be jetted from the nozzle; ~~[[,]]~~

wherein drive signals having are repeatedly applied a  
10 plurality of times to the electromechanical converting device to  
finely vibrate an ink meniscus without jetting an ink droplet  
from the nozzle, and said drive signals include: a voltage pulse  
of rectangular wave with a pulse width of  $(N_1)AL$  for expanding  
the volume of the ink channel, a first pause period with a width  
15 of  $(N_2)AL$ , a voltage pulse with a pulse of rectangular wave width  
of  $(N_3)AL$  for reducing the volume of the ink channel, and a  
second pause period with a width of  $(N_4)AL$ ; ~~are applied~~  
~~repeatedly plural times to the electromechanical converting~~

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device, ~~thereby a fine vibration of the ink meniscus is~~  
20 ~~conducted, while the ink is prevented from jetting from the~~  
~~nozzle,~~

where:

each of  $N_1$  and  $N_3$  is an integer of at least 2 ~~or more,~~

each of  $N_2$  and  $N_4$  is a real number of at least 1 ~~or~~

25 ~~more,~~ and

AL represents a half of an acoustical resonance period  
of the ink channel.

12. (Currently Amended) The ink-jet recording apparatus of  
claim 11, wherein each of  $N_2$  and  $N_4$  is an integer of at least 1  
~~or more.~~

13. (Original) The ink-jet recording apparatus of claim 11,  
wherein each of  $N_1$ ,  $N_2$ ,  $N_3$  and  $N_4$  is 4.

14. (Currently Amended) The ink-jet recording apparatus of  
claim 11, wherein a jetting drive voltage that ~~makes an~~ causes  
the ink droplet to jet be jetted from ~~a the~~ the nozzle ~~in the~~  
~~recording head and to record images,~~ is equal to a fine vibration  
5 drive voltage that ~~vibrates finely an~~ causes the ink meniscus to  
vibrate finely without ~~making~~ causing an ink droplet to ~~jet be~~  
jetted from the nozzle.

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15. (Currently Amended) The ink-jet recording apparatus of claim 14, wherein when the recording head is outside an image recording area, an ink refreshing drive to spew ink is carried out by driving the electromechanical converting device, and ~~each~~ 5 ~~of wherein~~ a jetting drive voltage ~~when the~~ for image recording ~~is conducted~~, a fine vibrating drive voltage that ~~makes~~ causes the ink meniscus to vibrate finely, and an ink refreshing drive voltage ~~is the same~~ are equal.

16. (Currently Amended) The ink-jet recording apparatus of claim 11, wherein the electromechanical converting device forms a partition wall between adjacent ink channels, and ~~is of~~ comprises a piezoelectric material that deforms ~~under~~ in a shear mode.

17. (Currently Amended) An ink-jet recording apparatus comprising:

a recording head having an ink channel and ~~(a)~~ a nozzle of ~~an ink channel in a recording head, from which an ink droplet is~~ 5 ~~jetted; and~~

~~(b)~~ an electromechanical converting device for changing a volume of the ink channel to ~~make the~~ cause an ink droplet to ~~jet~~ be jetted from the nozzle; ~~[[,]]~~

10 wherein fine vibration of an ink meniscus in the nozzle is  
conducted without causing the ink droplet to be jetted, in which

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the ink meniscus is pushed out from a surface of the nozzle by a peak distance at least substantially equal to ~~or more than~~ a nozzle radius, ~~and thereby, the ink meniscus is vibrated finely while the ink is prevented from flying from the nozzle.~~

18. (Currently Amended) The ink-jet recording apparatus of claim 17, wherein the ~~peak of the ink meniscus pushed out from a surface of the nozzle~~ distance is not more than three times the nozzle radius.

19. (Currently Amended) The ink-jet recording apparatus of claim 17, wherein drive signals ~~having~~ are applied to the electromechanical converting device, said drive signals including: a voltage pulse of rectangular wave with a pulse width of  $(N_1)AL$  for expanding the volume of the ink channel, a pause period with a width of  $(N_2)AL$  and a voltage pulse of rectangular wave with a pulse width of  $(N_3)AL$  for reducing the volume of the ink channel; ~~are applied to the electromechanical converting device,~~

where:

each of  $N_1$ ,  $N_2$  and  $N_3$  is an integer of at least 2, or more and

$AL$  represents a half of an acoustical resonance period of the ink channel.

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20. (Currently Amended) The ink-jet recording apparatus of claim 17, wherein ~~in the recording head,~~ a jetting drive voltage that ~~makes~~ causes an ink droplet to ~~jet~~ be jetted from ~~a the~~ nozzle ~~in the recording head,~~ a fine vibration drive voltage that  
5 ~~vibrates finely and~~ causes the ink meniscus to vibrate finely without ~~making~~ causing an ink droplet to ~~jet~~ be jetted from ~~a the~~ nozzle, and an ink refreshing drive voltage that causes ~~spews~~ ink to spew outside an image recording area  $[[,]]$  are ~~the same~~ equal.

21. (Currently Amended) The ink-jet recording apparatus of claim 17, wherein ~~a the~~ peak distance of ~~a fine vibration of the~~ ink meniscus from the nozzle is greater when the recording head is outside an image recording area ~~is greater than that of fine~~  
5 ~~vibration of an ink meniscus than~~ when the recording head is on a non-recording pixel in the image recording area.

22. (Currently Amended) The ink-jet recording apparatus of claim 17, wherein the electromechanical converting device forms a partition wall between adjacent ink channels, and ~~is of~~ comprises a piezoelectric material that deforms under in a shear mode.